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## HYDRAULIC LABORATORY RESEARCH

As the result of a proposal made by Dr. Schaffernak, of Austria, at the World Power Conference at Berlin in 1930, that "an organization be established for the purpose of interchanging, in the field of hydraulic engineering, the results of laboratory research and of observations of natural conditions corresponding thereto", the American committee of the World Power Conference asked the Bureau of Standards last January to serve as the exchange agency for the United States. The object of the proposed organization is to afford promptly to all the hydraulic laboratories throughout the world information as to the nature of the research which each is undertaking, thus permitting a closer coordination of the work. Results will be interchanged long before the final reports are published, and useless duplication of effort will be prevented.

The first step in organizing this service nationally in the United States was to compile and distribute to the hydraulic laboratories in this country a report covering the activities of these laboratories. As a result of the prompt cooperation of the individual laboratories, it was possible for the Bureau to issue on April 1, 1933, its first report of this kind, a mimeographed bulletin entitled, "Current Hydraulic Laboratory Research in the United States". The current number gives a history of the undertaking, and lists researches in progress in a large number of laboratories. These researches are reported uniformly under nine heads which give the principal facts needed by any one interested in looking up the details of these projects. The second report will be issued on July 1, and succeeding numbers will appear quarterly.

In addition to the above service, the Bureau will compile and issue annually a description of the hydraulic laboratories in the United States, their equipment and facilities for research, insofar as the heads of the laboratories will furnish the necessary information. It is planned to issue the first report of this kind on June 1.

Those desiring complete information as to this new service should address the Director, Bureau of Standards, Washington, D.C.

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### STUDIES OF MASONRY CEMENT—FREEZING, THAWING

The durability of the masonry cement, studied in the general investigation of this material, was determined by recording the number of "freezing and thawing" cycles withstood by each specimen.

The specimens (1 by 4 by 6 inches) were prepared from two mixes; 1:3 by weight, using 100 percent standard Ottawa silica sand and 1:3 by volume using one third pit run Ottawa sand and two thirds standard sand. The amount of water added produced normal flow as determined by Federal specification SS-C-181, F-3 g (3) a, b. The curing periods, prior to exposure to freezing and thawing, were 7 and 28 days in a damp closet, temperature 70° F. ±1, R.H. 98 percent. Specimens from each mix were made for each curing period. Specimens were made in triplicate for each mix and for each curing period. Forty-one masonry cements were represented by the specimens.

The specimens were placed flat-wise in pans and were one half submerged in water. Each "freezing and thawing" cycle consisted of placing pans so filled in a freezing chamber at +14° F. for 17 hours, then transferring the pans to water for 7 hours at room temperature.

Specimens failed in various ways, by spalling, crumbling, and by becoming so soft that they were washed away by the water.

Specimens made from 15 cements are still undergoing freezing and thawing treatment and are in good condition; the average number of cycles being 151. Test pieces from 22 cements failed in less than 10 cycles.

### ABRASIVE RESISTANCE OF NATURAL-STONE FLOOR TILES

The demand for data on the wearing qualities of floor-surfacing materials has led to a study of several marbles, limestones, etc., that are often used in decorative floors. It was necessary to design a testing machine for the purpose and compare its action with the actual wear on such materials under service conditions. During the past 4 years a considerable number of materials have been tested for Federal buildings, and data have been obtained on a variety of materials. Since there are frequent calls for such information the results have been assembled in a paper for publication. This contains results on 79 marbles, 39 limestones, 22 sandstones, 32 slates, 11 granites, 11 serpentines, 10 travertines, and a few miscellaneous materials that do not fall under the above classifications.

The means employed for expressing the results give a simple way of comparing different materials, the numerical values being proportional to abrasive resistance.

The marbles show a considerable range in wear values. The highest result obtained was 41.7 for a fine-grained black marble while the lowest, 6.7, was recorded for a rather loose-grained white marble. The average of the 79 marbles was 18.8, which is approximately equal to the values obtained for those marbles that are largely used for floor tile.

The average for 39 limestones was found to be 8.4. This group contained a few materials that would probably not be used in floors except in positions where the traffic is very light. The highest values for any limestones tested was 24.1.

Twenty-two sandstones gave an average of 13.3 and a range from 1.6 to 26.4. The abrasive resistance of this type of material seems to depend largely on the cohesive strength, since the wear results mainly in loosening and removing quartz grains from the surface exposed to abrasion. The highest value obtained for slate was 11.7 while the average was 7.7. The small range in abrasive resistance of this class of material indicates that there is little advantage of one slate over another for flooring purposes.

Although the granites are seldom used for floor-surfacing materials they are often used in the approach steps of buildings. The 10 granites tested showed uniformly high values with an average of 58.

The serpentines find frequent use in floors as decorative strips or inlays. The average of 11 serpentines was found to be nearly as high as that of granites, but a large range of values was evident.

The average of 10 travertines was found to be 13.7. The travertines used to a considerable extent in floors and steps gave values somewhat below the average for marble.

The wear values of the different stone now available should prove of special interest to architects in cases where several varieties of tile are combined for color scheme. Past experience has shown that selection based on color alone may lead to undesirable results.

### EFFECTS OF VARYING PARTICLE SIZE IN WHITEWARE

The formation of ceramic whiteware is essentially a process of fusion and of solution which is not permitted to proceed to completion. The process is a function not only of temperature but of the relative surface area of the materials used. The surface area per unit weight may vary considerably for the feldspar and the flint which, together, constitute about 50 percent of a ceramic whiteware body and which are ground commercially rather than mined in a finely divided state as is true of clay.

To study the effect of variations in particle sizes of the "raw materials" in whiteware bodies, and the possibilities of reducing manufacturing costs by lowering maturing temperatures, a feldspar and a flint of commercial grade were divided by means of an air elutriator into groups or "fractions" of varying particle sizes.

Various combinations of the several fractions of flint and of feldspar were incorporated in whiteware bodies. Specimens of these bodies were heated at 1,150°, 1,200°, 1,250°, 1,300°, and 1,350° C., and tested for linear shrinkareg, porosity, strength in bending, and linear thermal expansion. Relative fusion and solution in the body were estimated by microscopic examination.

In bodies containing only 15 percent feldspar, varying the particle size of this ingredient did not greatly affect shrinkage or porosity. However, for bodies containing 25 percent feldspar the porosity after heating at 1,200° C., could be reduced from 10 percent to practically zero by reducing the size of feldspar particles.

Varying the particle sizes of flint in bodies containing 35 percent of this ingredient affected their properties considerably. For example, the porosity of specimens heated at 1,250° could be reduced from 18 to 3 percent

Varying the particle sizes of both flint and feldspar produced the greatest changes in the properties of the bodies. A body containing commercially ground flint and feldspar and having a porosity of 18 percent after heating at 1,250° could be vitrified at this temperature when made with flint and feldspar of 10 micron (0.00039 inch) maximum particle diameter.

The data obtained indicate the possibility of vitrifying commercial ceramic whiteware, without the use of auxiliary fluxes, at temperatures significantly lower than are now required in the industry. Further studies of the effects of particle size of flint and feldspar in ceramic whiteware bodies, particularly with regard to the development of bodies which can be used advantageously on a commercial scale, are believed justified.

### GLASS PHASE IN FIRED CLAY MATERIALS

At the Columbus station, in the study of the glass phase in fired clay materials, a number of glasses have been prepared in the 4-component system $K_2O.CaO.Al_2O_3.SiO_2$. The surfaces of the tetrahedron representing this system are composed of the following 3-component systems: $K_2O.Al_2O_3.SiO_2$, $CaO.Al_2O_3.SiO_2$, $K_2O.CaO.Al_2O_3$, and $K_2O.CaO.SiO_2$, all of which are of ceramic importance. Glasses whose compositions are represented by points within the tetrahedron are formed whenever mixtures such as flint, feldspar, whiting, and china clay are subjected to high temperatures. A knowledge of the properties of all these glasses in the tetrahedron would be of considerable value to ceramists.

At present the portion of the tetrahedron lying between the 50 and 80 percent silica levels is being investigated. A preliminary study, using cones, was made to obtain some idea of the fluidity of these glasses. The raw materials used were potters' flint, calcium and potassium carbonates, and hydrated alumina. Two fusions were made of mixtures of these raw materials in the proper proportions. Each fusion was followed by a fine grinding of the mass in order to produce a homogeneous glass. The pulverized glass was then moistened with a solution of gum and molded into standard sized cones. These were fired in a muffle furnace, and the temperatures at which they deformed were noted. Two refractory areas were found in the 50 percent silica level: one at 20 to 25 percent $K_2O$, 5 to 10 percent $CaO$, and 15 to 25 percent $Al_2O_3$; and the other at 5 percent $K_2O$, 15 percent $CaO$, and 30 percent $Al_2O_3$. Two low melting areas, one high potash low alumina, the other at 5 percent $K_2O$, 20 percent $CaO$, and 25 percent $Al_2O_3$, were found. Both the refractory and the low-melting regions extended (as volumes) up to the 60 percent silica levels.

Those glasses were selected for further study which were not (1) too refractory to be fired at a temperature limited by the deformation of the container, a high alumina clay crucible,

nor (2) too corrosive due to high lime content, nor (3) too hygroscopic due to high potash.

### FREEZING TEMPERATURE OF SILVER

The International Temperature Scale is based upon a number of fixed points to which definite numerical values are assigned. One of these fixed points is the temperature of freezing silver which, in the above scale, is defined as 960.5° C. (about 1,761° F.).

In a recent intercomparison, the working temperature scales of the national standardizing laboratories of England, Germany, and the United States were found to be in agreement at all the fixed points with the exception of the silver point. A study was, therefore, made at the Bureau to determine the precautions which must be taken to secure reliable results in the use of this fixed point.

Three lots of silver of differing degrees of purity were studied and it was found that the purity must be higher than 99.99 percent if uncertainties of 0.1° C. from this cause are to be avoided.

The freezing point of silver is lowered when the metal is not protected from access of oxygen. The depression of the freezing point due to absorption of oxygen was measured under a number of experimental conditions. Graphite crucibles and covers were found to be as effective as a vacuum in protecting the silver from oxygen.

Research Paper No. 557 in the May number of the Bureau of Standards Journal of Research discusses this question in detail.

### "TIN-FREE" LEADED BEARING BRONZE

Commercial bronzes of high lead content generally contain tin to prevent lead segregation and to strengthen the matrix of the alloy. The usual maximum lead content of commercial leaded bronzes prepared by the ordinary foundry methods is about 28 percent. Segregation of lead is often excessive in brouze alloys containing 30 percent of lead or more. Under the sponsorship of the War Department, some experimental work has been done at the Bureau to develop a leaded bronze of high lead content, containing none of the so-called strategic metals, such as tin and antimony, and which could be used as a replacement alloy for the usual tin-base bearing alloys in many fields of service.

A series of copper-lead alloys containing 35 to 50 percent of lead, together with small additions of several other elements, was prepared. The microstructures were studied to determine the effect of the various additions on the dispersion and distribution of the lead particles throughout the copper-base matrix. Individual additions of barium, calcium, zirconium, and sulphur showed promise of aiding in the prevention of segregation of lead in leaded bronzes under the casting conditions used. Mechanical properties, such as resistance to wear, to impact (Charpy), to pounding (repeated impact), and strength in compression, which are of significance in the use of this type of alloy as bearings, were determined in comparison with those of similar commercially available alloys. The resistance to wear was determined only at approximately 20° C. (68° F.). All other tests were made at 20°, 100°, 150°, 200°, and 250° C. (68° to 480° F.). The results indicated that in most cases the silicon-zirconium-sulphur treated bronze containing approximately 35 percent lead, 0.4 percent sulphur, 1.5 percent silicon-zirconium alloy, and remainder copper, had properties equal or superior to any of the commercial alloys tested, some of which contained up to 6 percent tin.

Service tests were made on a set of connecting-rod and main bearings made of this alloy for use in airplane engines. These bearings were prepared by a commercial bearing manufacturer and were cast on steel backs. The main bearings, except for various amounts of scoring, stood up well. Some of the connecting-rod bearings failed, and metallographic examination of these bearings show that the lead in several cases was segregated, often in streaks approximately perpendicular to the bearing face and of a length equal to the entire thickness of the layer of bearing metal. The structure of both the used and unused main bearings made of the silicon-zirconium-sulphur treated leaded bronze differed from that in the connecting-rod bearings. The structure of the former was that which was characteristic of the specimens of this alloy prepared in the laboratory and upon which all of the laboratory tests were made. It is believed that this type of structure is essential for satisfactory results with this type of alloy and obviously can be secured in commercial bearings. The quite different structure existing in the connecting-rod bearings is believed to have resulted from factors in the manufac-

turing process which have not yet been sufficiently studied to permit exact control. These conditions are believed to have been in a large measure the cause of the bearing failures.

The complete report of this work will be published as Research Paper No. 551 in the May number of the Bureau of Standards Journal of Research.

### VIBRATIONS OF AIRCRAFT PROPELLERS

A brief note, to be published as Research Paper No. 556 in the Bureau of Standards Journal of Research for May, describes the essential features of a method of exciting resonant vibrations in mechanical systems, developed for the study of the vibrations of aircraft propellers. The propeller is mounted on the shaft of an ordinary direct-current motor, whose field is supplied by direct current in the usual manner. Alternating current is supplied to the armature with the result that an alternating torque is applied to the propeller. Because of the aerodynamic and inertial coupling, flexural vibrations of the blade are induced. If the frequency of the alternating current is made to coincide with a natural frequency of the propeller, the vibrations may be made sufficiently great to cause a fatigue failure.

### BLIND LANDING OF AIRCRAFT

The theory of operation and use of the radio system of landing aids now under service test at the Newark Municipal Airport, Newark, N.J., was outlined in Technical News Bulletin No. 192 (April 1933). Since March 15, the practicability of the system has been demonstrated by numerous landings in a hooded cockpit and also under fog conditions which interrupted all scheduled flying over a widespread area including the Newark Airport. The tests included a completely blind flight in dense fog from College Park, Md., to Newark Airport during which the ground was entirely hidden until the plane was within about 2,000 feet of Newark Airport at an altitude of somewhat over 100 feet. The results of the numerous demonstrations and tests at Newark corroborate performance data on the complete system accumulated during the experimental work at College Park. The precision of the system there developed has proved to be more than sufficient for the actual requirements of practical use at Newark.

Because of obstructions in the approach at College Park it was found necessary to provide a very precise and sharp runway localizing course. The transmitting and receiving equipments were so adjusted that, at 5 miles from the beacon, a deviation from the course of approximately 200 feet could readily be detected, while at a distance of one half mile, a deviation of 20 feet was easily discernible. At a distance of 4,000 feet, corresponding to the approach end of the field at Newark Airport, a deviation of 30 feet is noticeable. The runway at Newark is 500 feet wide. The actual path of the beacon course was checked at College Park periodically over a long interval and found to be fixed regardless of weather conditions and ground conductivity. To utilize the course sharpness available it was necessary to adopt a directional receiving antenna on the airplane which compensated automatically for a tendency to "weave" or "hunt" about the course and thus facilitated holding accurately to the course. The desired compensation was secured through the addition of an inclined wire running from the top of the vertical pole antenna back to the rudder fin.

Obstructions in the approach at College Park also necessitated close control of the landing path. Thus, it was necessary to clear a house chimney, approximately 1,500 feet from the edge of the field, by about 8 feet. The necessary fixed landing path was obtained by maintaining approximately constant power output at the landing beam transmitter and through the use of a landing beam receiving set having nearly constant amplification under all operating conditions. Calculation of the landing path at Newark shows that a drop of 10 percent in power output would raise the landing path, while an equal rise in power would lower it. At 3 miles from the landing beam transmitter, a change of 10 percent in power would result in a change of about 30 feet in an altitude of 630 feet, while at 2 miles, the change in altitude would be about 15 feet in an altitude of 280 feet. Over the far marker beacon it would be about 6 feet in an altitude of 100 feet, and over the boundary marker beacon, about 4 feet in 45 feet. These calculations have been verified experimentally. Experience indicates that, in practice, the output power of the landing beam transmitter can be readily maintained to within plus or minus 5 percent, so that the resultant

change in steepness of the landing path will be negligible.

The effect of variation in the constancy of amplification of the landing beam receiving set upon the landing beam path is about double that given in the foregoing for transmitter power variation; that is, a 10 percent change in the receiving set sensitivity produces twice the change in the landing path that results from a 10 percent change in the transmitter power. A simple receiving set has been designed at the Bureau of Standards for this service. Its sensitivity remains constant to within a few percent for all changes in applied voltages, aging of tubes, and other component parts. The sensitivity is constant for all filament voltages from 10 to 15 and for dynamotor supply voltages from 100 to 250. The variation of amplification with the life of a tube is negligible until the tube begins to lose emission. Reasonably frequent checking of the landing beam receiving set is therefore all that is necessary to insure a proper landing path. Once the landing path for a given airplane has been adjusted by means of the glide angle adjustment, this adjustment should be locked and the corresponding receiving set sensitivity measured. This is done through the use of a signal generator which is connected to the input terminals of the receiving set and the output voltage of which is varied until the "on-course" deflection is obtained on the horizontal pointer of the "combined instrument". The voltage corresponding to this deflection is then employed as a standard to which the receiving set is adjusted in future checks.

The results at Newark, where the landing path remained entirely constant for the past 2 months under a wide variety of weather conditions, confirms the foregoing data, particularly since not even a minor adjustment of the landing beam transmitter or of the landing beam receiving sets on the two test airplanes was required.

### LOW-FREQUENCY RADIO RECEIVING MEASUREMENTS AT THE BUREAU OF STANDARDS IN 1931 AND 1932

A report recently prepared for publication in the Proceedings of the Institute of Radio Engineers, gives the monthly and annual averages of field intensities of 10 European and 3 American low-frequency transatlantic radio stations, between frequencies of 16 and 24 kc, and the field intensity averages of atmospherics on 15 and 23 kc, observed at the Bureau of Standards, for the years 1931 and 1932. Measurements were made by the telephone current comparison method. Annual average curves of daylight field intensities of European signals and afternoon atmospherics on 23 kc are shown with the corresponding yearly averages of sunspot numbers. A monthly average field intensity curve of Tuckerton WCI, 18.4 kc, shows a return from the high values obtained in 1930 and 1931 to the average value of previous years. Some correlations between polarization of the reflected wave and sunspot numbers derived from a year of continuous recording of Tuckerton WCI, on loop antennas, are shown. The possibility of obtaining an independent value for the ground wave from such a series of observations is suggested.

### IMPROVED INSTRUMENT FOR MEASURING RADIOACTIVE MATERIALS

The usual electroscopes employed in measuring the radiations from radioactive materials are tedious to use because of the time consumed in determining the rate of motion of the gold leaf. This must be repeated several times to eliminate variations in the rate of motion due to accidental disturbances. In Research Paper No. 550, which will be published in the May number of the Bureau of Standards Journal of Research, a simple 2-stage vacuum tube amplifier is described which makes possible an instantaneous reading of the intensity of the radiation from the specimen on a pointer-type microammeter. In addition to being more rugged than a gold-leaf electroscope, the amplifier is readily adaptable to a greater variety of uses.

### SCREW MICROMETER GAGE FOR RUBBER SPECIMENS

In Research Paper No. 549, which will be published in the May number of the Bureau of Standards Journal of Research, the use of screw micrometers in place of dial gages for measuring the dimensions of soft rubber test specimens is discussed, and three types of screw micrometer gages which are being used for this purpose are described. The difficulty in determining the point at which the spindle and anvil are just in contact with a soft specimen is overcome in these gages by the use of electrical contacts and a suitable indicating device. By this means the compression of the rubber during the gaging process has been reduced to a point where measurements can be made with a precision of about

0.0002 inch. Comparative figures are given showing the dimensions of soft rubber parts measured with micrometer gages, dial gages, and where possible, computed from volumes. The time required to make measurements with the micrometer gage is somewhat greater than with the dial gage. The advantage lies in the inherent accuracy of the screw and the fact that the compression of the material at contact points is greatly reduced.

#### PHOTOELASTIC STUDY OF RUBBER

When transparent rubber is stretched, it exhibits the well-known phenomenon of double refraction. A study is being made of the double refraction of rubber as a function of the stress and the composition. The measurements cover the range of stresses from 1 to 100 bars (the bar is a unit of pressure, equal to 14.50 lb./in.$^2$), which correspond, for the samples employed, to elongations from about 20 to 600 percent. One rubber compound which was studied in some detail was made according to the following formula:

| | *Parts by weight* |
|---|---|
| Pale crepe rubber | 100.0 |
| Zinc oxide (Kadox) | 1.0 |
| Stearic acid | 1.0 |
| Sulphur | 2.0 |
| Tetramethylthiuramdisulphide | 0.3 |
| Total | 104.3 |

In order to ascertain the effect of the sulphur content on the photoelastic behavior of rubber, similar compounds were made with 4, 5, and 6 percent of sulphur, respectively, but without the tetramethylthiuramdisulphide.

The measurements are expressed in terms of the stress-optical coefficient in brewsters. A coefficient of 1 brewster signifies that when a beam of light is passed through the substance rendered doubly refracting by the stress, the extraordinary ray is retarded 1 Angstrom unit behind the ordinary ray when the thickness of the sample is 1 millimeter and the stress is 1 bar. Thus the brewster is $10^{-13}$ cm$^2$ dyne$^{-1}$. The double refraction at any value of the stress is related to the stress-optical coefficient, $C$ by the equation,

$$n_o - n_e = 10^{-7} CS$$

where $n_o$ and $n_e$ are the refractive indices for the ordinary and the extraordinary rays, respectively, and $S$ is the stress in bars.

Since the refractive indices, and hence the stress-optical coefficient, may vary with the wave length of the light, all measurements were made with monochromatic light of wave length 5,461 A°. U. obtained from a mercury arc.

The stress-optical coefficient for the accelerated rubber compound of the formula given above is about 2,000 brewsters at a stress of 2.5 bars (elongation, 20 percent), and increases to 2,100 brewsters at 13 bars (elongation, 110 percent) and remains constant within the probable experimental error of ±10 brewsters up to a stress of 55 bars (elongation, 330 percent). At higher stresses rubber of this composition exhibits optical creep. The compounds which were vulcanized with sulphur alone, without the organic accelerator, do not show a similar constancy of the stress-optical coefficient with varying elongation. The values for the coefficient range from 2,000 to over 3,300 brewsters and appear to be a function of both the stress and the sulphur content.

Inasmuch as stress-optical data may not be familiar to investigators in other fields, it may be of interest to note that the coefficient for rubber is high in comparison with coefficients for most other transparent materials. Inorganic crystalline substances and glasses have coefficients in the range 1 to 5 brewsters, celluloid has a coefficient of about 10 brewsters, and bakelite, a coefficient of about 50 brewsters. Gelatines, however, have coefficients of 5,000 to 20,000 brewsters and are the only common materials higher than rubber in this respect.

#### EVALUATION OF "HANDLE" AND "DRAPE" OF CLOTH

The "handle" or "feel" and the "drape" of fabrics are of importance to the user of textiles, for example in clothing and home furnishing, as well as to the textile designer, and to the textile finishing mill which must produce fabrics having a given "handle" or "drape." They are psychological qualities which are commonly expressed only in the vaguest terms. Two instruments have been developed recently in the textile section of the bureau for the evaluation of certain of the physical attributes of cloth that affect the sensations which contribute to "handle" and "drape." One is called the flexometer, the other the compressometer.

The flexometer provides a means for measuring the flexural attributes of cloth, paper, sheet rubber, and similar

materials. A pair of test specimens of standard dimensions are mounted in opposite angles formed by two vertical intersecting plates, one of which is fixed and the other movable on a spindle. The work done in folding the specimens to various angles between the plates, the work recovered when they are allowed to unfold, and the work lost are determined. These quantities are a measure, respectively, of flexural work, flexural resilience, and flexural hysteresis of the specimens. They are related to the stiffness, and creaseability of the cloth.

The compressometer provides a means for measuring the compressional attributes of cloth and similar materials. With it, the thickness can be measured under a known pressure which can be increased or decreased gradually and continuously. Thus the thickness under a given pressure and the change in thickness under either increasing or decreasing pressure can be determined. The compressibility and compressional resilience of the material are computed from these data. These attributes are related to softness or hardness and springiness as appreciated by squeezing the cloth between the fingers.

Descriptions of the flexometer and the compressometer, together with data illustrative of the results obtained with these instruments, will appear in the May and June issues, respectively, of the Bureau of Standards Journal of Research.

### EFFECT OF TEMPERATURE ON LITHOGRAPHIC PAPERS

Further information has been obtained at the Bureau to assist lithographers in overcoming misregister of successive color prints, which is the most prolific source of waste in the industry.

Five samples of lithographic papers, representative of the different types of papers most commonly used in offset printing, have been studied at eight different temperatures, ranging from 68° to 110° F. Dimension changes, the most common cause of misregister, were determined by measuring specimens approximately 24 by 24 inches to 0.001 inch, and moisture content changes were determined by weighing somewhat smaller samples on a chemical balance to 0.0001 gram. The relative humidity was maintained constant at 45 percent throughout so that the temperature was the only factor varied.

The temperature changes resulted in regular moisture-content changes, the average change being 0.2 percent per 10° F. temperature change for the five papers studied. The moisture content varied inversely with the temperature; that is, the moisture content of the paper went down as the temperature went up and increased as the temperature fell.

All changes in moisture contents of the papers were accompanied by proportionate dimensional changes. The same relationship between moisture content and dimensions was found to exist as when moisture-content changes resulted from humidity variations, and a single smooth curve was obtained when plotting moisture contents against dimensions with both temperature and relative humidity varied. Therefore it appears that the dimensions of such papers vary directly with moisture content regardless of whether moisture-content changes result from variations in relative humidity or temperature, at least within the range ordinarily encountered. Temperature changes had the same effects on the papers of relative-humidity changes except that they were of different magnitude and in the reverse order. For example, in the vicinity of 45 percent relative humidity, the papers were affected in the same manner and to approximately the same extent by an increase in temperature of 40° F. as by a decrease in relative humidity of 9 points.

### AIR PERMEABILITY OF PAPER

Considerable attention is being devoted at the Bureau to precise measurement of air permeability of paper. The rather large differences in the facility with which different kinds of paper permit the passage of air are significant in a great many ways. The effectiveness of sheating paper used in the walls of houses depends upon their airtightness in order to minimize heat losses from infiltration. Many food products are incased in airtight wrappers to prevent the absorption of objectionable odors and to preserve the freshness of the food. A certain degree of resistance to permeation of air is necessary in cigarette paper to insure the proper draft through the burning tobacco. Air permeability and dielectric strength are intimately related in electric-cable insulation. Air permeability is more or less intimately related with the rate of absorption of organic liquids in the case of saturating felts or paper (for making roofing, treated wrappers, cable insulation, bakelite), in printing

papers and in grease-proofed papers. In addition to these direct applications, air permeability is an extremely important tool in the study of the structure of paper and in determining the relation of pore space to other properties of paper and fibrous sheet materials.

Nearly a score of air permeability measuring devices have been described in the literature, a few of which have been used rather extensively. A preliminary experimental study has been made at the Bureau of such of these as were available. Although some of these testing devices are suitable for the ordinary requirements in testing certain kinds of paper, none of them adequately fulfills the requirements of a reference standard, since they are not adapted to cover the large range of air permeability represented by paper and boards in general, and since the uncertainty in the measurement is often rather large. Perhaps the chief source of uncertainty is in leakage in the apparatus or at the edges of the specimen, and the absence of simple means of detecting such leakage. Instances were found in which the error from leakage was as great as the air permeability itself. Some other deficiencies noted are: Small testing area, inconstancy of driving pressure, lack of sensitivity, and length of time required to test papers of low permeability. After making the preliminary survey it seemed advisable to design a new instrument suited to precision testing and adapted to accommodate practically any kind of paper or fiber board and this work is now in progress.

### MEETING OF AMERICAN PHYSICAL SOCIETY

The one hundred and eighty-fourth regular meeting of the American Physical Society was held in Washington, April 27, 28, and 29. Meetings on the first and second days were held at the Bureau of Standards and on the last day at the National Academy of Sciences. The following papers were presented by members of the Bureau's staff:

An absolute determination of the ohm, by H. L. Curtis, Charles Moon, and C. Matilda Sparks.

An absolute determination of the ampere, by H. L. Curtis and R. W. Curtis.

The effect of turbulence on the rating of cup anemometers, by H. L. Dryden, W. C. Mock, Jr., and G. B. Schubauer.

Theory and experiment in fluid dynamics, by L. B. Tuckerman.

Studies of boundary layer flow at the Bureau of Standards, by H. L. Dryden.

The present status of knowledge of pressure loss for flow in curved pipes, by G. H. Keulegan.

Capacity of overflow troughs, by K. H. Beij.

The National Hydraulic Laboratory, by H. N. Eaton.

Superconductivity of tin at radio-frequencies, by F. B. Silsbee, R. B. Scott, F. G. Brickwedde, and J. W. Cook.

Thermal conductivity of metals in the range 0° to 600° C., by M. S. Van Dusen and S. M. Shelton.

Spontaneous Recombination and the effect of vapor pressure in a caesium discharge, by F. L. Mohler.

An inspection tour of the Bureau's new hydraulic laboratory, for the special benefit of those attending the hydrodynamics session, was arranged on the afternoon of April 27.

### MEETING OF ACOUSTICAL SOCIETY OF AMERICA

The ninth meeting of the Acoustical Society of America was held at the Bureau of Standards on May 1 and 2. In all, 18 papers were presented, including a special lecture on "Nature's Music", by Dr. W. J. Humphreys, of the United States Weather Bureau, on the evening of May 1.

Two papers were presented by members of the Bureau's staff: Physical methods of exploration for oil-bearing structures, by E. R. Shepard, and Experimental evidence of non-logarithmic sound decay, by V. L. Chrisler and Catherine Miller.

### NATIONAL CONFERENCE ON WEIGHTS AND MEASURES

The Bureau regrets that it has been found advisable to cancel the 1933 meeting of the National Conference on Weights and Measures which normally would be held early in June. After considering the entire situation the executive committee of the conference decided by a unanimous vote that it would be unwise to attempt to hold a meeting this year. When the 1932 meeting was abandoned it was hoped that one could be held as usual in 1933, but continuance of abnormal economic conditions has made it certain that but few people would have been able to attend.

In this emergency the Bureau particularly desires to be of service to weights and measures officials, equipment manufacturers, and others asso-

ciated with the conference, and will do everything possible to bridge the gap caused by the cancellation of the meeting. Anyone with weights and measures problems to discuss is urged to submit them to the Bureau, where they will be given every attention within the limits set by the funds available.

### NEW AND REVISED PUBLICATIONS ISSUED DURING APRIL 1933

#### Journal of Research[1]

Bureau of Standards Journal of Research, vol. 10, no. 4, April 1933 (RP nos. 540 to 548, inclusive). Price, 25 cents. Obtainable by subscription.

#### Research Papers[1]

(Reprints from Journal of Research)

RP522. The elimination of background "noise" in sensitive pulse amplifiers; L. F. Curtiss. Price, 5 cents.

RP523. The pressure of saturated water vapor in the range 100° to 374° C.; N. S. Osborne, H. F. Stimson, E. F. Fiock, and D. C. Ginnings. Price, 10 cents.

RP524. Some fusion properties of ground coat enamels as influenced by composition; W. N. Harrison and B. J. Sweo. Price, 5 cents.

RP526. Temperature effect and its elimination in Geiger-Müller tube counters; L. F. Curtiss. Price, 5 cents.

RP527. Operation of thick-walled X-ray tubes on rectified potentials; L. S. Taylor and C. F. Stoneburner. Price, 5 cents.

RP528. Apparatus for comparison of length of gages; C. Moon. Price, 5 cents.

RP529. Clay in concrete; D. A. Parsons. Price, 5 cents.

RP530. Reference tables for platinum to platinum-rhodium thermocouples; Wm. F. Roeser and H. T. Wensel. Price, 5 cents.

#### Circulars[1]

C402. Sundials; R. E. Gould. Price, 5 cents.

[1] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D.C. Subscription to Technical News Bulletin, 50 cents per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and Republic of Panama); other countries, 70 cents. Subscription to Journal of Research, $2.50 per year; other countries, $3.25. Subscription to Commercial Standards Monthly, $1 per year; other countries, $1.60.

#### Simplified Practice Recommendations[1]

R32–32 (2d ed.). Concrete building units. Price, 5 cents.

R53-32 (2d ed.). Steel reinforcing spirals. Price, 5 cents.

R57-32 (2d ed.). Wrought-iron and wrought-steel pipe, valves, and fittings. Price, 5 cents.

R89-32 (2d ed.). Coated abrasive products. Price, 5 cents.

R102-33. Granite curbstone. Price, 5 cents.

R139-32. Commercial laundry extractors. Price, 5 cents.

R140-32. Commercial laundry flatwork ironers. Price, 5 cents.

R141-32. Commercial laundry tumblers. Price, 5 cents.

R142-32. Commercial laundry washers. Price, 5 cents.

R143-33. Paper cones and tubes (for textile winding). Price, 5 cents.

#### Commercial Standards[1]

CS9-33 (2d ed.). Builders' template hardware. Price, 5 cents.

#### Commercial Standards Monthly[1]

Commercial Standards Monthly, vol. 9, no. 10, April 1933. Price, 10 cents. Obtainable by subscription.

#### Technical News Bulletin[1]

Technical News Bulletin No. 192, April 1933. Price, 5 cents. Obtainable by subscription.

### LETTER CIRCULARS

It is the intent of the Bureau to distribute single copies of these mimeographed letter circulars on request only to those parties having a special interest in the individual letter circular. Economy necessitates limitation in the number of copies issued. It is not the intent to supply parties with a copy of each letter circular issued during the month. Letter circulars are necessarily of a temporary nature designed to answer numerous inquiries on a given subject. Requests should be addressed to the Bureau of Standards, Washington, D.C.

LC368. Routine testing of lubricants and liquid fuels. This letter circular describes why it is not feasible at the present time for the Bureau to make routine tests on lubricants and liquid fuels for the general public.

LC369. Survey of city planning and related laws in 1932.

[1] See footnote in first column.

LC370. Regional planning commissions or organizations in the United States.

LC371. City planning commissions in the United States.

LC372. Use of flexible steel gages in gaging the mesh of gill nets.

### OUTSIDE PUBLICATIONS [2]

Brooks, D. B., and Allen, H. H., Some improvements in psychrometry, Journal, Washington Academy of Sciences (Menasha, Wis.), vol. 23, no. 3, p. 121; March 15, 1933.

Steele, Sydney, Infrared radiation from an Otto cycle engine, Industrial and Engineering Chemistry (Washington, D.C.), vol. 25, p. 388; April 1933.

Priest, Irwin G., A proposed scale for use in specifying the chromaticity of incandescent illuminants and various phases of daylight, Journal, Optical Society of America Cornell University (Ithaca, N.Y.), vol. 23, p. 41; February 1933.

Taylor, L. S., and Rheinbold, G. A., A remotely operated switch for Roentgen dosage meters, The American Journal of Roentgenology and Radium Therapy (Detroit, Mich.), vol. 29, no. 3, 416; March 1933.

Eiseman, J. H., Smith, F. A., and Merritt, C. J., The effect of altitude on the limits of safe operation of gas appliances, American Gas Journal (New York, N.Y.), p. 19; April 1933.

Wilkie, J. B., Mercerization of cotton for strength, American Dyestuff Reporter (New York, N.Y.), vol. 22, p. 217; March 27, 1933.

Harris, Milton, The combination of silk and wool with positive and negative ions, American Dyestuff Reporter (New York, N.Y.), vol. 22, p. 273; April 24, 1933.

Bowker, R. C., and Wallace, E. L., The influence of pH on the deterioration of vegetable-tanned leather by sulphuric acid, Journal, American Leather Chemists Association (Ridgway, Pa.), vol. 28, no. 3, p. 125; March 1933.

Wallace, E. L., and Kanagy, J. R., The influence of sodium chloride and magnesium sulphate on the hydrolysis of leather by sulphuric acid, Journal, American Leather Chemists Association (Ridgway, Pa.), vol. 28, no. 4, p. 186; April 1933.

[2] "Outside publications" are not for distribution or sale by the Government. Requests should be sent direct to publishers.

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